

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

To:

see form PCT/ISA/220

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43bis.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/GB2004/005182

International filing date (day/month/year)
09.12.2004

Priority date (day/month/year)
12.12.2003

International Patent Classification (IPC) or both national classification and IPC
G01J9/00, G02B27/46, G02B26/06, G06E3/00

Applicant
THOMAS SWAN & CO. LIMITED

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☒ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA"). However, this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of three months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:



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**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/GB2004/005182

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
☐ a sequence listing
☐ table(s) related to the sequence listing
 - b. format of material:
☐ in written format
☐ in computer readable form
 - c. time of filing/furnishing:
☐ contained in the international application as filed.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority for the purposes of search.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/GB2004/005182

Box No. II Priority

1. ☐ The following document has not been furnished:

- ☐ copy of the earlier application whose priority has been claimed (Rule 43*bis*.1 and 66.7(a)).
- ☐ translation of the earlier application whose priority has been claimed (Rule 43*bis*.1 and 66.7(b)).

Consequently it has not been possible to consider the validity of the priority claim. This opinion has nevertheless been established on the assumption that the relevant date is the claimed priority date.

2. ☐ This opinion has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rules 43*bis*.1 and 64.1). Thus for the purposes of this opinion, the international filing date indicated above is considered to be the relevant date.
3. ☒ It has not been possible to consider the validity of the priority claim because a copy of the priority document was not available to the ISA at the time that the search was conducted (Rule 17.1). This opinion has nevertheless been established on the assumption that the relevant date is the claimed priority date.
4. Additional observations, if necessary:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-18
	No: Claims	
Inventive step (IS)	Yes: Claims	1-18
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-18
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

**Reasoned statement with regard to novelty, inventive step or industrial applicability;
citations and explanations supporting such statement**

1. Reference is made to the following documents:

**D1: ADVANCED PHASE-CONTRAST TECHNIQUES FOR WAVEFRONT SENSING
AND ADAPTIVE OPTICS; VORONTSOV M ET AL, PROCEEDINGS OF THE SPIE,
VOLUME 4124, PAGES 98-109; 2000**

**D2: HOLOGRAPHIC OPTICAL SWITCHING: THE "ROSES" DEMONSTRATOR;
CROSSLAND W A ET AL, JOURNAL OF LIGHTWAVE TECHNOLOGY, VOLUME
18, NUMBER 12, PAGES 1845-1854; DECEMBER 2000**

2. Claims 1 and 12 do not satisfy the requirements of Article 6 PCT for the reasons set out in paragraphs 4.1 to 4.5 below. For the purposes of examination with regard to novelty and inventive step, claims 1 and 12 have been interpreted as if this objection had been overcome in the manner set out in paragraphs 5.1 and 5.2, below.

- 3.1 Claim 1, construed in this manner, appears to satisfy the requirements of Article 33(2) and 33(3) PCT for the following reasons:

The document D1 is regarded as being the closest prior art and discloses [see figure 1 and page 101, section 2.3 ("Differential Zernike filter")]: A method of measuring amplitude and phase variations in a spatially coherent [the skilled person would appreciate that the use of Zernike filters would require the beam to have some degree of spatial coherence] beam of light comprising

- causing the beam to be incident upon a first phase distribution ["LC or MEMS actuator"],
- in a region of said spatial array, causing the phase distribution to change to a new value while retaining the first phase distribution outside the region [the phase shift is only introduced in a small central region of the plate (see page 99, paragraph 2) and is a "controllable phase shift switching between two states" (page 101, section 2.3)]
- in the Fourier plane [the photo array is in the Fourier plane of the controllable phase shift plate], determining the change in intensity resulting from the change in phase distribution [the intensities corresponding to the two phase distributions are subtracted to give the change], and
- determining the amplitude and phase variations of the beam [the phase is calculated,

the intensity is measured by the photo array, and knowing the intensity and phase, the amplitude is also known].

- 3.2 Claim 1 differs (in one respect) from D1 in that the beam whose amplitude and phase variations are determined is the beam *as incident on the spatial array*. In D1, the beam whose amplitude and phase variations are determined is the beam *as incident on the input lens*, so that the beam incident on the phase modulator is the Fourier Transform of the wavefront to be measured. This arrangement of figure 1b of D1 (the Fourier Transform of the wavefront to be measured being incident on the phase modulator) is characteristic of a *global* determination of the phase and amplitude. The arrangement of claim 1 (the wavefront to be measured being incident on the phase modulator) is characteristic of the *local* determination of the phase and amplitude of the present invention. The two approaches are quite different, and it would not be obvious for the skilled person to adapt one to the other.
- 3.3 An arrangement similar to that of the present invention is disclosed in D2 (see e.g. figure 1). However, D2 is concerned with photonic switching and there is no hint in this document to adapt the arrangement to the measurement of amplitude and phase.
- 3.4 Hence, the combination of features of claim 1 is neither disclosed nor suggested in the available prior art, and claim 1 is therefore considered to involve an inventive step (Article 33(3) PCT). Independent claims 2, 12 and 15 appear to satisfy the requirements of Article 33(3) PCT for the reasons set out above, *mutatis mutandis*. All other claims, being dependent on claims 1, 2, 12 or 15, also satisfy the requirements of Article 33(3) PCT.
- 4.1 Claim 1 does not satisfy the requirements of Article 6 PCT for the following reasons:
- 4.2 It is clear from the application documents (see e.g. page 7, lines 4-11) that the method of the present invention relates to a *local* determination of the phase and amplitude (i.e. a determination of the phase and amplitude in the neighbourhood of a particular point), and not a *global* determination of the phase and amplitude (i.e. a determination of the phase and amplitude at substantially all points across the wavefront simultaneously, as in D1). The mention of a "measurement region" in claim 1 alludes to this distinction, but there is no clear statement that it is in this region that the phase and amplitude are determined.

Hence, methods of global determination of phase and amplitude which are unsupported by the description are not clearly and explicitly excluded from the claim (Article 6 PCT).

- 4.3 Claim 1 mentions "determining the change in intensity". It is clear from the application documents (see e.g. page 7, line 10 *et seq.* and page 17, line 23 *et seq.*) that according to the method of the present invention the amplitude and phase variations are determined *on the basis of this measured change in intensity*. This final step has, however, been omitted, from claim 1, thus leaving open the possibility of embodiments in which the amplitude and phase variations are determined on a basis other than that of the measured change in intensity. Such embodiments are not supported by the description (Article 6 PCT).
- 4.4 Claim 1, in the light of the description, also leaves a doubt as to precisely which parameters are measured. It is clear from the application documents (see e.g. page 6, lines 5-7) that according to the method of the present invention, the amplitude and phase variations of the beam *as incident on the "spatial array"* are determined. Although this is hinted at in claim 1 by the use of the term "incident", a doubt remains in the light of the description. For example, in the embodiment of figure 5, the beams 201 and 202 are described as "the incident beams", implying that in the method according to claim 1 it is the amplitude and phase variation of these beams [i.e. as incident on lens (200)] that are measured. In fact, it appears that what is actually measured is the amplitude and phase variation of the wavefront which falls onto the surface of the spatial array (203), which is the Fourier Transform of the "incident" beams 201,202. This ambiguity is contrary to Article 6 PCT.
- 4.5 The objections of paragraphs 4.1 - 4.4 apply also to claim 12 *mutatis mutandis*.
- 4.6 Independent claims 2 and 15 do not satisfy the requirements of conciseness of Article 6 PCT, as these claims should have been drafted to be dependent on claims 1 and 12.
- 5.1 For the purposes of examination with regard to novelty and inventive step, claim 1 has been interpreted as if the above objections under Article 6 PCT had been overcome as follows:
- A method of measuring amplitude and phase variations in a spatially coherent beam of light comprising

- causing the beam to be incident upon a spatial array displaying a pixellated first phase distribution,
- in a measuring region of said spatial array, **said measuring region corresponding to a neighbourhood of a point in the beam where it is required to measure the amplitude and phase variations**, causing the phase distribution to change to a new value while retaining the first phase distribution outside the measuring region
- in the Fourier plane, determining the change in intensity resulting from the change in phase distribution; **and**
- **determining the amplitude and phase variations, in the measuring region, of the beam as incident on the spatial array, on the basis of said change in intensity.**

5.2 For the purposes of examination with regard to novelty and inventive step, claim 12 has been interpreted as if the above objections under Article 6 PCT had been overcome (for the processor, see e.g. page 27, lines 7-19 and figure 4) as follows:

Apparatus for measuring amplitude and phase variations in a spatially coherent beam of light, the apparatus comprising

- a pixellated spatial array, each pixel being controllable to apply any of plural phase shifts to input light, whereby the array displays a desired distribution of phase modulation,
- means for causing the array to display a first selected distribution of phase modulation;
- means for changing the first distribution in a measuring region of said spatial array, **said measuring region corresponding to a neighbourhood of a point in the beam where it is required to measure the amplitude and phase variations**, to assume a new distribution while retaining the first phase distribution outside the measuring region,
- means disposed in the Fourier plane for determining a change in intensity of light resulting from the change in phase distribution.
- **signal processing means adapted to determine the amplitude and phase variations, in the measuring region, of the beam as incident on the spatial array, on the basis of said change in intensity.**